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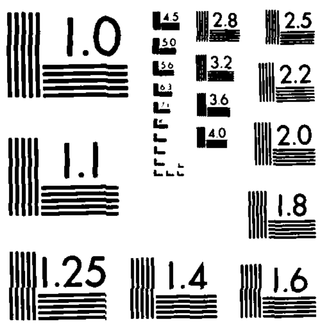

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US Army Corps
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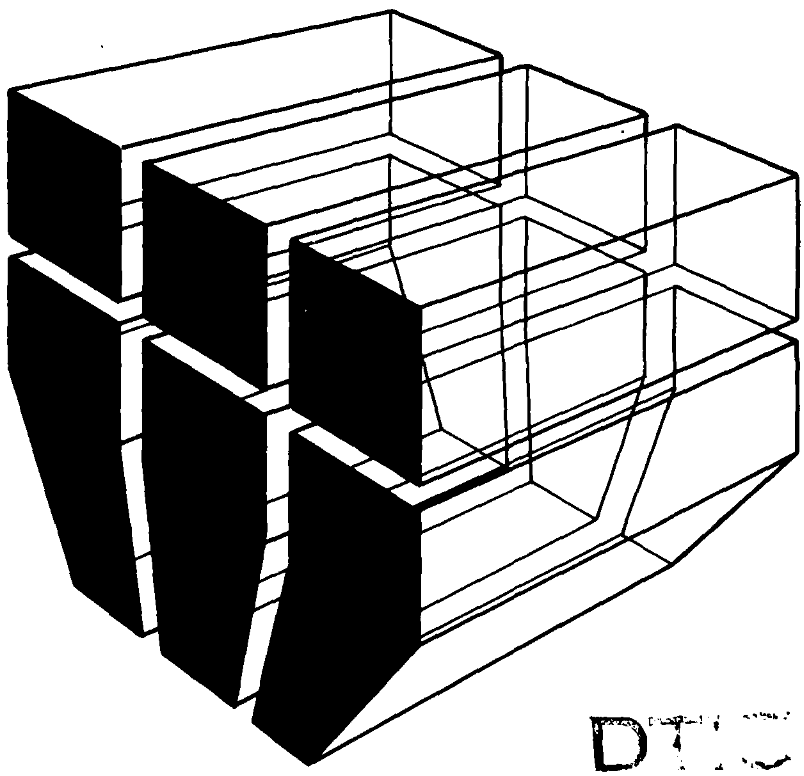
Research Laboratory

SPECIAL REPORT E-85/06
March 1985

AD-A152 236

HEAT RECOVERY INCINERATION:
A SUMMARY OF OPERATIONAL EXPERIENCE



by
R. A. Ducey
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K. L. Griggs
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the results of a study to determine how reliably heat recovery incinerators (HRIs) are performing in the field. Information on equipment used, operating parameters, economic factors, and problems encountered in operating HRIs was provided by 52 installations throughout the United States. Twenty of the most common problems experienced with HRIs in the field are discussed. In each case, the percentage of installations experiencing each problem is also provided. Military personnel can use this information to evaluate HRIs for military applications. (Continued)

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Overall, the majority of HRI users were found to be generally satisfied with the performance of their systems. However, they indicated that efficiency could be improved and the amount of maintenance reduced. The most appropriate HRI must be chosen on a site-specific basis. It has been noted that the most successful applications have been at installations which thoroughly researched their waste supply and steam demands before project design, chose the HRI manufacturer carefully, and properly trained their operators.

FOREWORD

This research was conducted for the Office of the Assistant Chief of Engineers (ACE) under Project 4A162781AT45, "Energy and Energy Construction"; Technical Area D, "Energy Systems/Alternative Sources"; Work Unit 007, "Heat Recovery Incineration/Refuse-Derived Fuel." The work was performed by the Energy Systems Division (ES), U.S. Army Construction Engineering Research Laboratory (USA-CERL). Mr. B. Wasserman, DAEN-ZCF-U was the ACE Technical Monitor.

Mr. R. G. Donaghy is Chief of USA-CERL-ES. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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CONTENTS

HEAT RECOVERY INCINERATION: A SUMMARY OF OPERATIONAL EXPERIENCE

1 INTRODUCTION

Background

Recent increases in both energy prices and landfill costs have stimulated interest in the concept of waste incineration with heat recovery. In many parts of the country, existing sites for solid waste disposal are nearing the end of their useful lives. Onsite incineration provides an alternative to hauling solid waste to a landfill; furthermore, coupling the incinerator to a heat recovery boiler will result in the added benefit of energy savings.

The military is also concerned with these waste disposal problems. Therefore, the U.S. Army Construction Engineering Research Laboratory (USA-CERL) is actively involved in a program to help military personnel evaluate heat recovery incinerator (HRI) technologies.

Purpose

The purpose of this report is to summarize results of a study to determine how reliably existing HRIs are performing in the field.

Approach

USA-CERL gathered information during the summer of 1983 from 52 HRI installations located throughout the United States. The sites were selected from a listing published by the U.S. Conference of Mayors (see Appendix). Information was obtained from each that described:

1. The specific physical plant

2. Equipment performance relative to problems experienced.

The information was evaluated and the most common problem areas defined. Based on this data, general guidelines for choosing an HRI technology were outlined.

Scope

The equipment described in this report does not represent an all-inclusive cross section of available equipment. The installations included here have an incineration capacity in the range of primary interest to the Army--5 to 50 tons per day (tpd) of solid waste. In addition, given the informal nature of this study, these findings are not intended to endorse any particular technology or manufacturer. The objective is rather to provide a general overview of the operating experience gained from existing equipment.

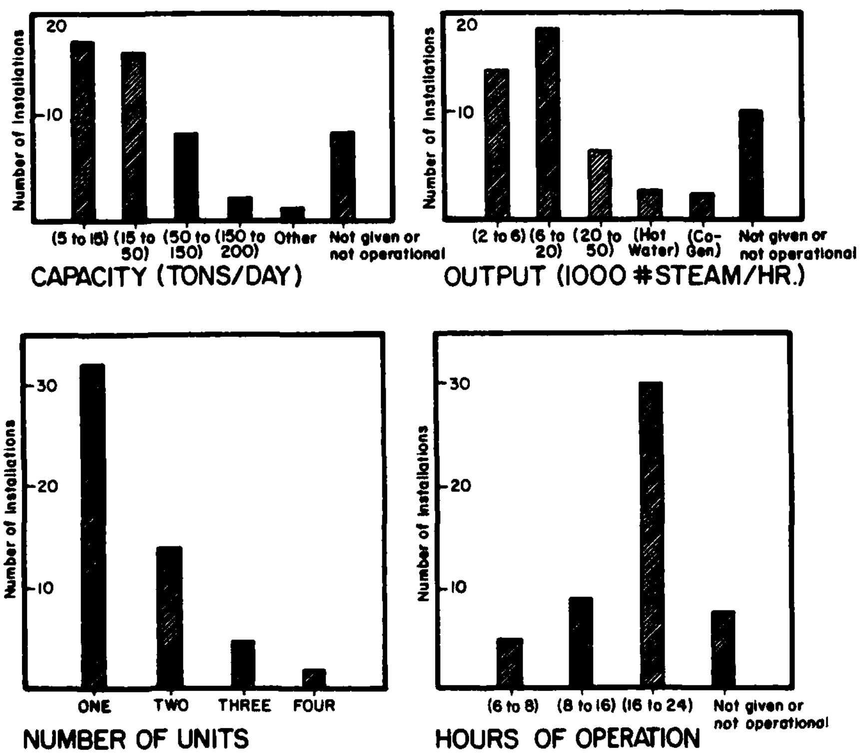
2 INSTALLATION DESCRIPTIONS

Figure 1 describes the physical plants included in this study. The figure determines the equipment, the basic operating parameters, and certain economic factors for the sites evaluated.

Figure 1a plots the number of installations within a given range of incinerator capacity (tpd), output production (pounds of steam per hour), number of units, and hours of operation per day. Figure 1b summarizes these same sites by boiler type and the type of waste burned. Figure 1c shows the initial project cost, yearly operational and maintenance budgets, number of plant personnel, and years of operation (since 1983).

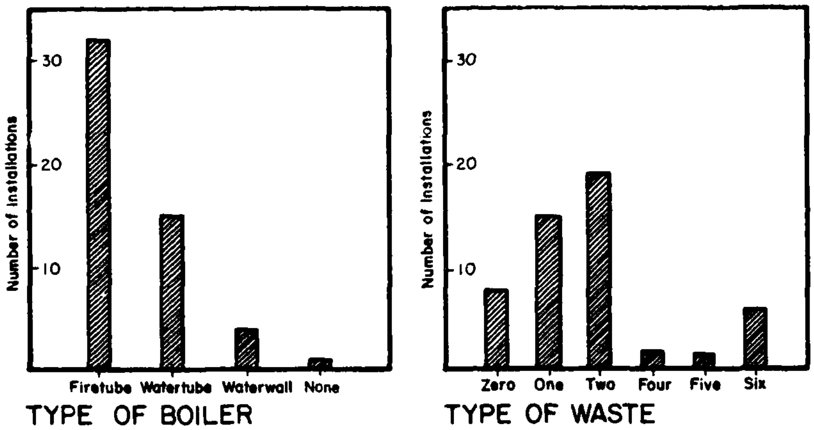
Combining this information produces the following "typical" or composite profile of this group of HRI installations:

- Capacity of 20 tpd of type II waste
- Modular, starved-air, dual-chamber design

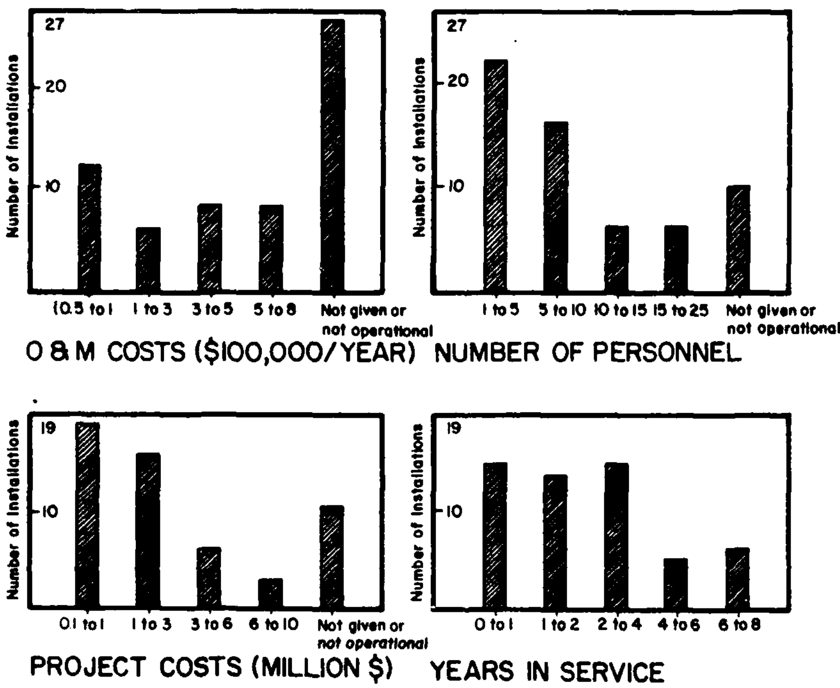


a. Capacity, production, units, and hours of operation.

Figure 1. Description of installations.



b. Boiler type and waste type.



c. Initial project cost, yearly O&M budgets, number of personnel, and years of operation.

Figure 1. (Continued)

- Single unit with a fire-tube boiler, producing 10,000 lb (4000 kg) of steam per hour

- Operates 24 hours per day, 6 days per week, with five personnel

- Constructed within the past 3 years at a cost of less than $2 million*

- Operating budget of $200,000 per year

*All dollar amounts quoted in this study are based on a 1983 dollar evaluation.

3 EQUIPMENT

Figure 2 summarizes the information obtained from HRI installations on equipment performance. The 20 most common problem areas are itemized on the horizontal axis, and the percentage of installations reporting each problem is represented by the height of the bar on the vertical axis. The following text provides a more detailed explanation of each problem.

Castable Refractory (71 Percent)

Castable refractory was by far the most frequently reported problem. When it is noted that several installations did not use castable refractory in the combustion chamber, this high incidence is even more significant. The severity of the problem ranged from the need for minor patching to complete refractory replacement in both primary and secondary chambers.

In most cases, minor patching was done during regular maintenance to repair damage caused when the charging and internal rams pushed bulky waste through the system. Operators avoided this situation as much as possible by removing particularly damaging materials from the waste stream before incineration. They also experimented with different patching materials to find the most durable ones.

When a complete replacement of the refractory was required, it was usually because the initial lining was not fully cured or did not have a high enough temperature rating. (Some operators took a year or more to learn how to regulate the temperature in the combustion chambers to minimize refractory damage from thermal shock.) Some manufacturers now offer complete fire-brick refractories for starved-air incinerators; most users feel that the greatly reduced maintenance costs these refractories provide justify the higher initial investment.

Under-Fire Air Ports (35 Percent)

Under-fire air ports plug easily and require frequent cleaning. To solve this problem, operators have tried enlarging the orifices and periodically purging them with steam. One user designed a three-chambered, water-cooled system that helped reduce the plugging; however, most of these problems were treated through regular maintenance.

Tipping Floor (29 Percent)

The universal complaint about tipping floors is that the storage area was too small. Operations with a 24 hr/day schedule were particularly affected because waste was delivered during an 8- to 12-hr period and allowed to accumulate on the tipping floor. It then took 12 to 16 hr to reduce the pile to a manageable level.

The logical solution would be to increase the floor area (which many operators did), but this was not always possible. The best way to avoid this

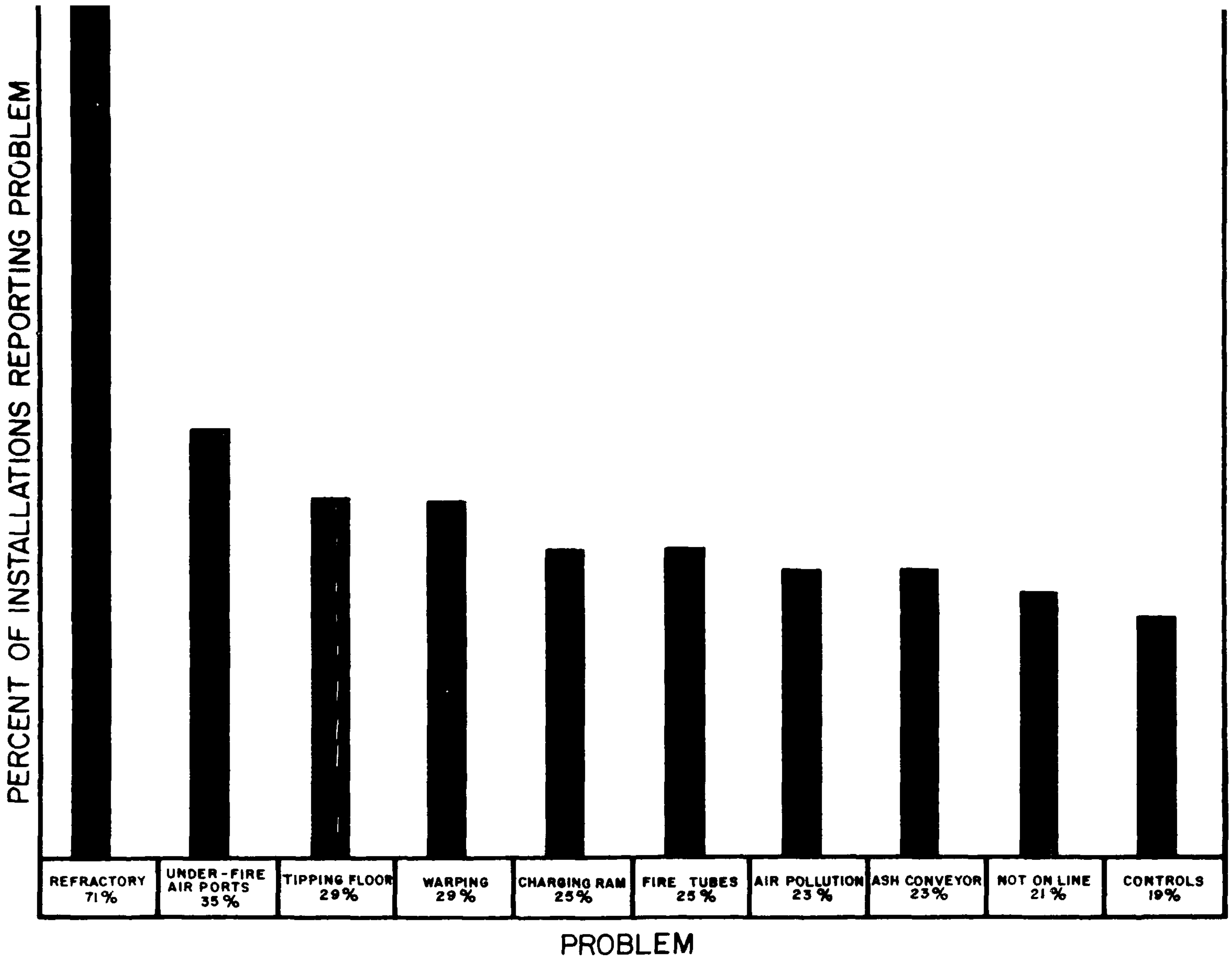


Figure 2. Equipment problem incidence.

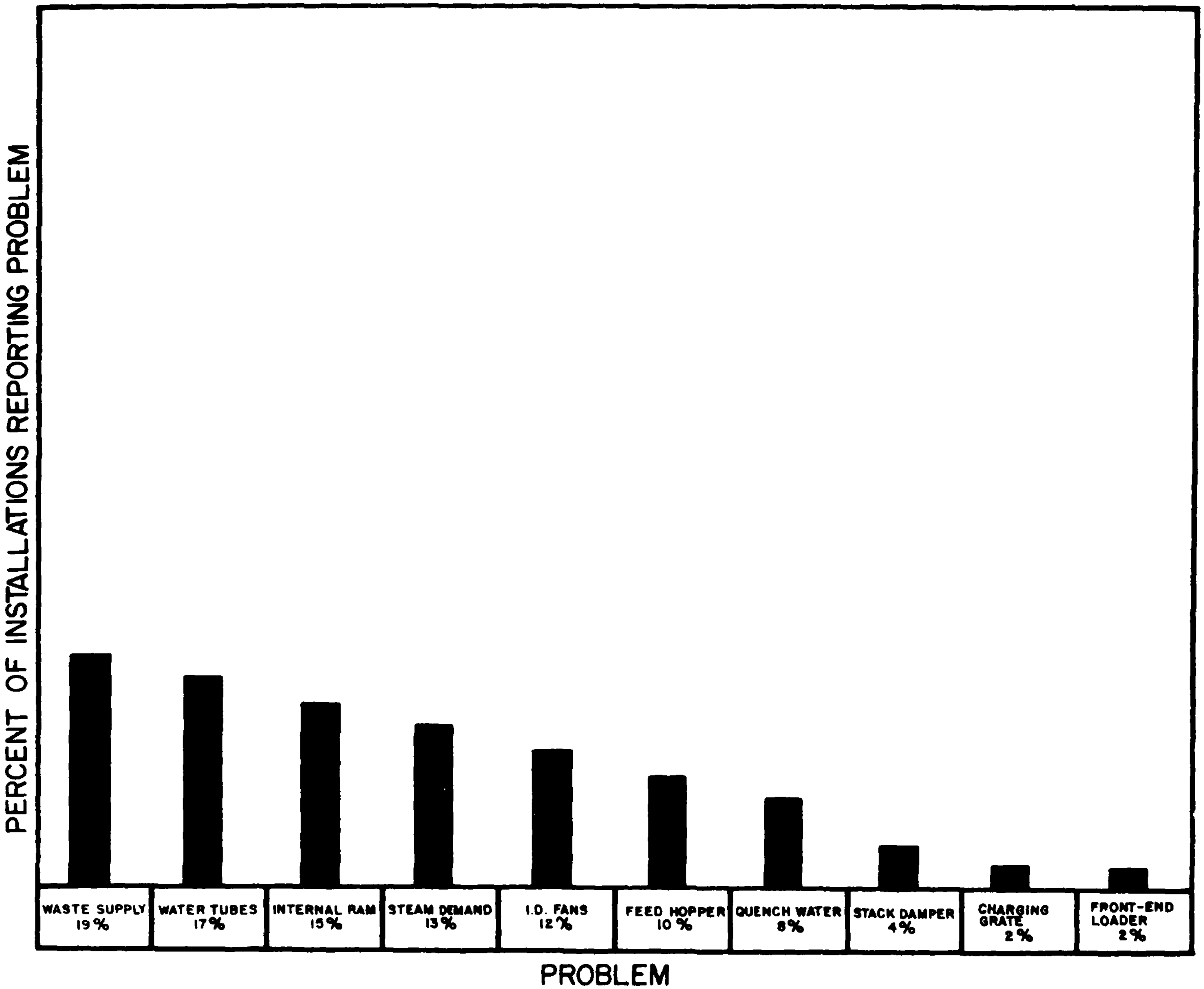


Figure 2. (Cont'd).

problem is to predict the amount of waste that will be moving through the system and design the tipping floor accordingly. In most cases, the preferred ratio is 125 to 150 sq ft/tpd capacity.

Warping (29 Percent)

Stack dampers, charging rams, charging doors, and water tubes may warp if the incinerator reaches excessive temperatures. In starved-air systems, such warping can cause a critical loss of seal, resulting in excessive combustion air in the primary chamber. To avoid warping, an adequate temperature monitoring and control system is necessary.

Charging Ram (25 Percent)

The most common problems with charging rams result from deficiencies in the system hydraulics. These include ruptured hoses, leaking seals, and loose fittings. In addition, a warped charging ram may jam, causing loss of adequate seal. In one case, this condition caused blowback from the combustion chamber, which started fires in the feed hopper. Jamming can also result when bulky wood and steel waste become wedged between the ram face and the sides of the feed hopper.

Fire Tubes (25 Percent)

Problems with tubes plugging were noted in roughly half the sites with fire-tube boilers. This was usually caused by poor combustion which resulted from high moisture content of the waste or other operational problems. Regularly scheduled cleanout is the best solution to this problem, with the frequency of this maintenance dictated by waste fuel characteristics; this ranges from once per week to twice per year. Also, use of soot-blower systems that are available for fire-tube boilers may help mitigate the problem.

Air Pollution (23 Percent)

Pollution control was a major concern of operators during the design phase. However, in many cases, emission performance regulations were met easily when the equipment was brought on-line and tested. The problems usually occurred in states with more stringent emission codes, but most were solved by addition of a baghouse, an electrostatic precipitator, or a chemical additive system.

Ash Conveyer (23 Percent)

Several of the small systems did not use an ash conveyer. When one was used, several problems were noted: (1) the conveyer jams easily, (2) the conveyer is too lightweight, and (3) the drag-chain breaks. For a system with multiple units and a common conveyer, these problems are critical, because a malfunction of the ash conveyer could incapacitate the entire system.

Experience with these problems has stressed the importance of having individual conveyers in plants with multiple incinerators.

System Not On Line (21 Percent)

Although the percentage experiencing this critical problem seems high, several large manufacturing plants had suffered general plant reductions because of unfavorable economic conditions. In these cases, there was no real problem with the HRI. Other installations had lost their major steam customer. However, some sites were never on line because of constant, unexpected maintenance requirements.

Controls (19 Percent)

Installations more than 5 years old were generally the ones with electromechanical control problems. These controls were often judged to be inadequate, unreliable, and outdated, and many operators were interested in the new microprocessor controls.

Poor placement of the control panel was also a problem. The most preferred location is one that is isolated from the main traffic areas, but still provides an overview of the entire operation.

Inadequate Waste Supply (19 Percent)

No plant was receiving more waste than it could burn; in fact, in 19 percent of the cases, an inadequate waste supply prevented the plant from operating at its design capacity. Municipal HRIs with this problem were looking to outside communities for additional waste. Some industrial HRIs in the same situation were offering contracts to private haulers, with tipping fees lower than those charged by the local landfill. One industrial user who had extra space shut down the HRI during the summer months and stored paper and wood waste for use the following winter.

Water Tubes (17 Percent)

Most water-tube heat-recovery boilers use a heat transfer fin on the tubes to increase thermal efficiency. This works well until the fins collect the heavy fly ash that low quality waste produces. The ash buildup significantly decreases thermal efficiency. Clearing the tubes of fly ash was a major maintenance problem of more than half the users of water-tube boilers. Less common, but more severe problems arose when the tubes warped or ruptured.

Internal Ram (15 Percent)

Internal rams move the waste fuel through the primary chamber, discharging ash and noncombustibles into the quench pit. Like the charging ram, they can jam, but they are much less accessible, so maintenance is more

difficult. In some cases, the internal ram did not move the ash all the way into the pit (stroke too short). Consequently, there was an accumulation at the back of the combustion chamber. Ash can also build up behind the ram face, preventing it from returning completely. This may cause a loss of seal, which makes starved-air conditions difficult to maintain.

Low Steam Demand (13 Percent)

Unless electrical cogeneration or absorption chiller systems were included with the steam production boiler, most installations experienced a seasonal decrease in steam demand. In most cases, the boiler was simply shut down and heat from the incinerator vented through the dumpstack. However, the operators reporting low steam demand as a problem (13 percent) were concerned with more than seasonal fluctuations. Most of them had lost a major steam customer, and in a few cases the plant had closed.

Induced-Draft Fans (12 Percent)

Induced-draft fans created either too much draft or not enough draft, burned out motors quickly, and required frequent rebalancing. Another factor was the fan's inability to tolerate wide temperature fluctuations. By trial and error, most operators were able to find an acceptable combination of wheel dimension and motor speed to fit their specific needs.

Feed Hopper (10 Percent)

At one installation, a feed hopper located about floor level slowed the operation considerably because waste had to be lifted into the hopper. One excess-air grate system had a funnel feed hopper whose slope was so shallow that the waste was "hanging up" and not falling into the incinerator. Other operators simply felt a different hopper size or configuration would better suit their needs.

High pH of Quenchwater (8 Percent)

Most installations used a closed quenchwater system and a high pH level was not a problem for them. However, those who were returning quenchwater to the city system had to chemically treat the water. Some avoided redundant treatment systems by using water from the blowdown tank for makeup quenchwater.

Stack Damper (4 Percent)

A few operators had problems with warped or poorly controlled stack dampers.

Charging Grate (2 Percent)

Charging-grate problems were common among excess-air grate incinerators. Operators of these plants generally felt that the grate was too lightweight, causing it to jam and require frequent component replacement (as often as every 6 months).

Front-End Loaders (2 Percent)

The common complaints with front-end loaders were that they (1) required more maintenance than expected, (2) lost traction when the waste and tipping floor were watered down for dust control, or (3) were not physically sized to match the dimensions of the feed hopper.

4 SUMMARY AND EVALUATION

Although subjective, these findings indicate how current HRI technology is being applied and what types of operational problems are occurring. The operator's opinion of the incinerator was an important part of the study. A summary of those opinions would be:

1. Seventeen percent were very pleased with their systems, had experienced only minor maintenance problems, and felt that performance met or exceeded the manufacturers' claims.

2. Seventy-one percent were generally satisfied with the performance of their systems but indicated that, with a few minor changes, maintenance could be reduced and efficiency improved.

3. The remaining 12 percent were not happy with their systems, experiencing severe problems either with them or with the steam market. However, in many of these cases, the operators thought that the basic HRI concept was still valid.

Even with a more detailed analysis, it would be difficult to endorse a particular type of equipment or manufacturer for all applications. That decision must be made on a case-by-case basis. However, based on the experience of the operators in this study, some general guidelines are evident. The most successful installations were the ones that (1) properly researched their waste supply and steam demand prior to project design, (2) found a manufacturer who could supply a system that met well-defined performance specifications and had a history of project followup, and (3) trained operating personnel to anticipate problem situations and to work within the system's limitations.

APPENDIX: Heat Recovery Incinerator Facilities Studied

	NAME	CITY	STATE	INCINERATOR MANUFACTURER	TONS/DAY	UNITS	WASTE TYPE	BOILER MANUFACTURER	BOILER TYPE*
01.	City of Batesville	Batesville	AR	Consumat	50	1	2	Vierson	WT
02.	City of Blytheville	Blytheville	AR	Consumat	50	2	2	not installed	-
03.	City of North Little Rock	N. Little Rock	AR	Consumat	100	4	2	Vierson	WT
04.	City of Osceola	Osceola	AR	Consumat	50	2	2	Vierson	WT
05.	Lockheed	Sunnyval	CA	Consumat	25	1	1	Vierson	WT
06.	Pratt and Whitney	East Hartford	CT	E.C.P.	0	-	-	not given	-
07.	City of Windham	Windham	CT	Consumat	108	3	2	Vierson	WT
08.	Rolscreen	Pella	IA	Consumat	24	1	1	Vierson	WT
09.	Cassia County	Burley	ID	Consumat	50	1	2	Vierson	WT
10.	General ELectric	Mattoon	IL	Kelley	13	1	1	York-Shipley	FT
11.	International Harvester	Moline	IL	Kelley	10	2	1	York-Shipley	FT
12.	Olin Brass Co.	Alton	IL	E.C.P.	50	2	1	York-Shipley	FT
13.	Pillsbury Co.	Springfield	IL	E.C.P.	15	1	1&0	North American	FT
14.	Colgate Palmolive Co.	Jeffersonville	IN	E.C.P.	25	1	-	York-Shipley	FT
15.	Monarch Rubber	Baltimore	MD	E.C.P.	15	1	1&6	York-Shipley	FT
16.	City of Auburn	Auburn	ME	Consumat	200	4	2	Vierson	WT
17.	Maine Rubber	Westbrook	ME	E.C.P.	16	1	6	York-Shipley	FT
18.	Ford Motor Co.	Saline	MI	Comptro	25	1	1&0	ABCO	FT
19.	Genesee Township	Genesee	MI	Consumat	100	2	2	Vierson	WT
20.	Goodyear Tire Co.	Jackson	MI	Lucas Amer	36	1	6	not given	-
21.	Anderson Corp.	Bayport	MN	Kelley	48	2	1	York-Shipley	FT
22.	City of Red Wing	Red Wing	MN	Consumat	72	2	2	Vierson	WT
23.	St. John's University	Collegeville	MN	Basic Env	65	1	2	Deltak	WW
24.	St. Louis Univ. Hosp.	St. Louis	MO	E.C.P.	25	1	2&4	York-Shipley	FT
25.	Park County	Livingston	MT	Consumat	70	2	2	Vierson	WT
26.	Freightliner	Mt. Holly	NC	E.C.P.	13	1	1	York-Shipley	FT
27.	General Electric	Hickory	NC	E.C.P.	11	1	0	Eclipse	FT
28.	Digital Equipment	Merrimack	NH	Kelley	30	1	1	York-Shipley	FT
29.	City of Groveton	Groveton	NH	E.C.P.	25	1	0	Eclipse	FT
30.	Lamprey Solid Waste Coop	Durham	NH	Consumat	108	3	2	Vierson	WT
31.	Lockheed Electronics	Watchung	NJ	Kelley	12	1	0&5	York-Shipley	FT
32.	Cattaraugus County	Cuba	NY	Clear Air	112	3	2	Eclipse	FT
33.	Columbia Pres. Hosp.	New York	NY	Morse Boulger	36	1	2&4	Eclipse	FT
34.	Corning Glass Works	Corning	NY	Comptro	25	1	0&2	Eclipse	FT
35.	Rockwell International	Marysville	OH	Kelley	24	1	1	York-Shipley	FT
36.	Xerox Education Center	Columbus	OH	Kelley	12	1	0	York-Shipley	FT
37.	City of Miama	Miami	OK	Consumat	108	3	2&6	Vierson	WT
38.	International Paper Co.	Lewisburg	PA	E.C.P.	20	1	-	Eclipse	FT
39.	Reynolds Metal	Darlington	PA	Comptro	25	1	0&5	Eclipse	FT
40.	William Rorer Corp.	Ft. Washington	PA	Kelley	15	1	1	York-Shipley	FT
41.	City of Dyersburg	Dyersburg	TN	Consumat	100	2	2	Vierson	WT
42.	City of Lewisburg	Lewisburg	TN	Cico	60	1	2	Eclipse	FT
43.	Sumner County	Gallatin	TN	O'Connor	200	2	1&2	Keller	WW
44.	Trane Co.	Clarksville	TN	E.C.P.	20	1	1	York-Shipley	FT
45.	City of Waxahachie	Waxahachie	TX	Clear Air	60	2	2	Eclipse	FT
46.	City of Hampton	Hampton	VA	Detroit St	200	2	2	Keeler	WW
47.	City of Harrisonburg	Harrisonburg	VA	M.B.	100	2	2	Zurn	WW
48.	City of Salem	Salem	VA	Consumat	100	2	2	Vierson	WT
49.	Alan-Bradley	Milwaukee	WI	Kelley	15	1	1	York-Shipley	FT
50.	Continental Can	Milwaukee	WI	Kelley	15	1	1	York-Shipley	FT
51.	K. W. Muth	Sheboygan	WI	Kelley	10	2	0	York-Shipley	FT
52.	Waste Research and Reclamation	Eauclaire	WI	Comptro	15	1	5	Eclipse	FT

*WT = Watertube, FT = Firetube, WW = Waterwall

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